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Growth and Prospective Development of Hardwoods and Loblolly Pine Seedlings on Clearcut Areas

by

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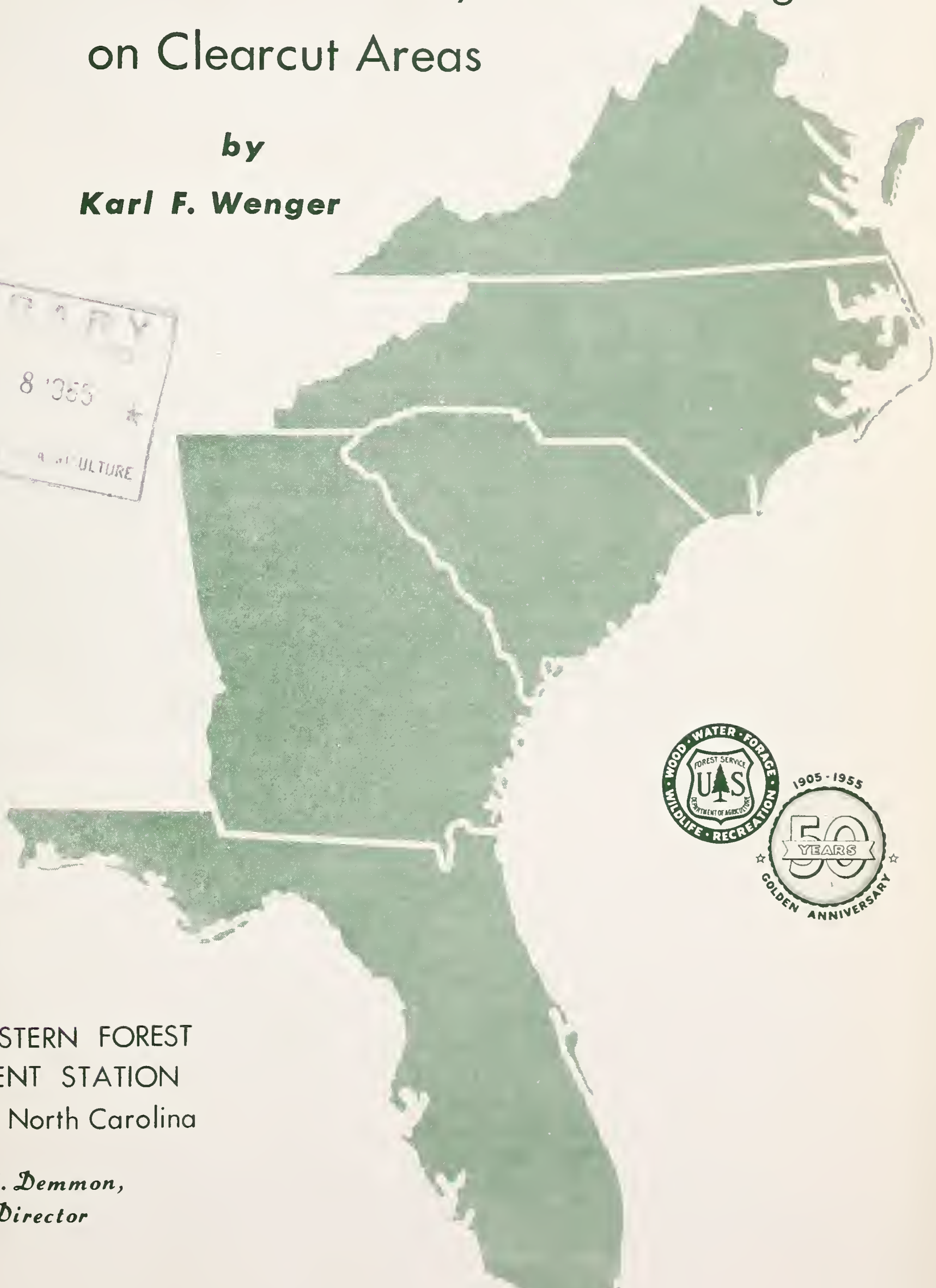

SOUTHEASTERN FOREST
EXPERIMENT STATION
Asheville, North Carolina

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U. S. DEPARTMENT OF AGRICULTURE - FOREST SERVICE

GROWTH AND PROSPECTIVE DEVELOPMENT OF HARDWOODS AND LOBLOLLY PINE SEEDLINGS ON CLEARCUT AREAS

By
Karl F. Wenger

When natural regeneration is relied upon in the even-aged management of loblolly pine, a stocking survey should be made as soon as possible to find out whether the tract can be left as it is, whether cultural measures are needed, or whether drastic treatment to prepare a fresh seedbed is necessary.

To make a reliable estimate of dominant and potentially dominant seedlings, the owner needs facts on growth and development of pine seedlings and their hardwood competitors. Clear cuttings made in the Bigwoods Experimental Forest[1] in every year from 1946 to 1952 furnished ideal conditions for getting the necessary information.

DEVELOPMENT OF HARDWOODS AFTER CLEAR CUTTING

Two complementary methods of studying hardwoods were chosen. The first concerned the area occupied by the new hardwood growth in relation to time since cutting, soil characteristics, and seedbed preparation. The second dealt with the height growth and lateral expansion, in relation to the same factors of age, soil, and seedbed, of five species of hardwood sprout clumps deemed the most serious competitors of pine seedlings.

Area Occupied by New Hardwood Growth

The area occupied by the new hardwood growth was estimated on square, 1/10-acre plots by the line-intercept method. Sixty-seven plots were distributed over three soil groups, two soil surface conditions, and several ages of hardwood sprout growth based on time since clear cutting the pine stand. The soil groups were (1) well and imperfectly drained, with friable subsoils; (2) well and imperfectly drained, with plastic subsoil; and (3) poorly drained, with plastic subsoils. All burning was done within 1 year after logging and in late summer, from late August till early October.

1/ Maintained in Hertford County, North Carolina, by the U. S. Forest Service, in cooperation with the Camp Manufacturing Company, Inc. Franklin, Virginia.

Figure 1 shows the trends of hardwood area growth on each set of environmental conditions beginning with an initial coverage of 10 percent, which was typical of fresh clear cuttings in the experimental forest. Pine seedlings are not entirely barred from the area classed as hardwood. Many openings that are too small to measure, and the thin crowns of some hardwoods such as sumac, sassafras and hercules club, admit enough light for rapid growth of pine seedlings (fig. 2).

Notice particularly the effect of fire. Fire increased the growth of hardwood cover on the two well-drained soil groups by about equal amounts but reduced it about twice as much on the poorly-drained soils. Without burning, the hardwood cover grew fastest on the poorly-drained plastic soils, slower on the well-drained friable soils, and slowest on the well-drained plastic soils. After burning, growth was fastest on the well-drained friable soil, slower on the well-drained plastic soil, and slowest on the poorly-drained plastic soil. The increased growth on the well-drained soils probably was caused by the mineral nutrients and nitrogen released from the litter by burning, but the reduced growth on poorly-drained soils isn't explained so easily. Possibly aeration was poorer after burning because these soils are more susceptible to puddling and packing upon exposure.

Growth of Sprout Clumps

The species chosen for individual study were sweetgum (*Liquidambar styraciflua* L.), red maple (*Acer rubrum* L.), the red oak group (*Quercus* spp.), dogwood (*Cornus florida* L.), and waxmyrtle (*Myrica cerifera* L.). Eight hundred and forty-nine sprout clumps of these species were distributed, although not equally, among the three soil groups, the two surface conditions (burned and unburned), winter and summer cutting, and were up to 5 years of age.

Mean heights adjusted for differences in diameter of stump and age of sprout are shown in table 1.

For sweetgum, red maple, and the red oaks, the outstanding finding was that burning significantly increased their height growth on the well-drained friable soils. Height growth was not affected by late summer burning on the well-drained plastic soils, and on the poorly-drained plastic soils was significantly reduced only in red oak.

Without burning, these three species responded to soils in different ways, but after burning they all grew fastest on the well-drained friable soils, slower on the well-drained plastic soils, and slowest on the poorly-drained plastic soils. The data for waxmyrtle and dogwood were insufficient for similar comparisons because these species were limited and erratic in occurrence.

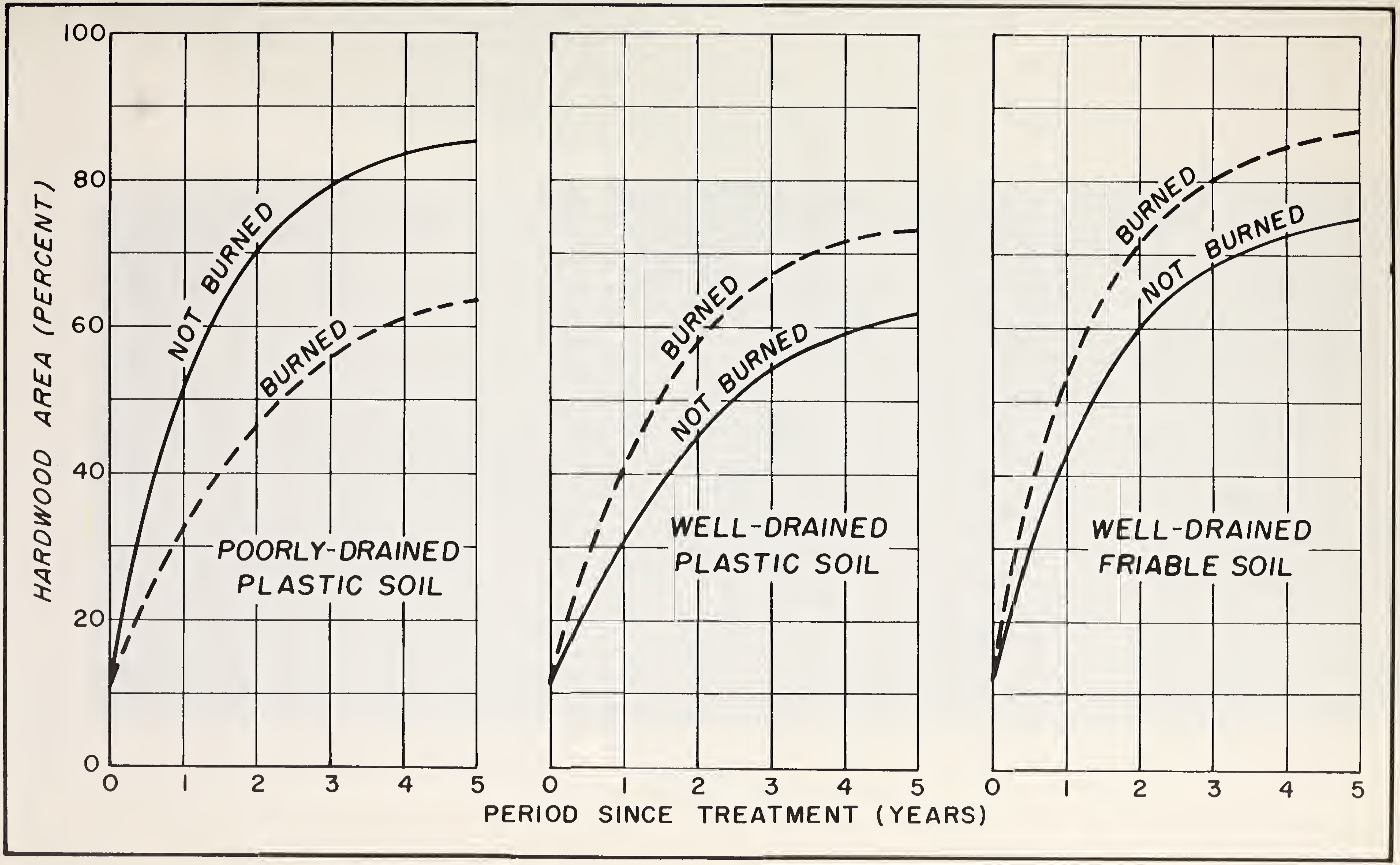

Figure 1. --The increase in area occupied by new hardwood growth in clear cuttings, by soil groups and surface treatment.

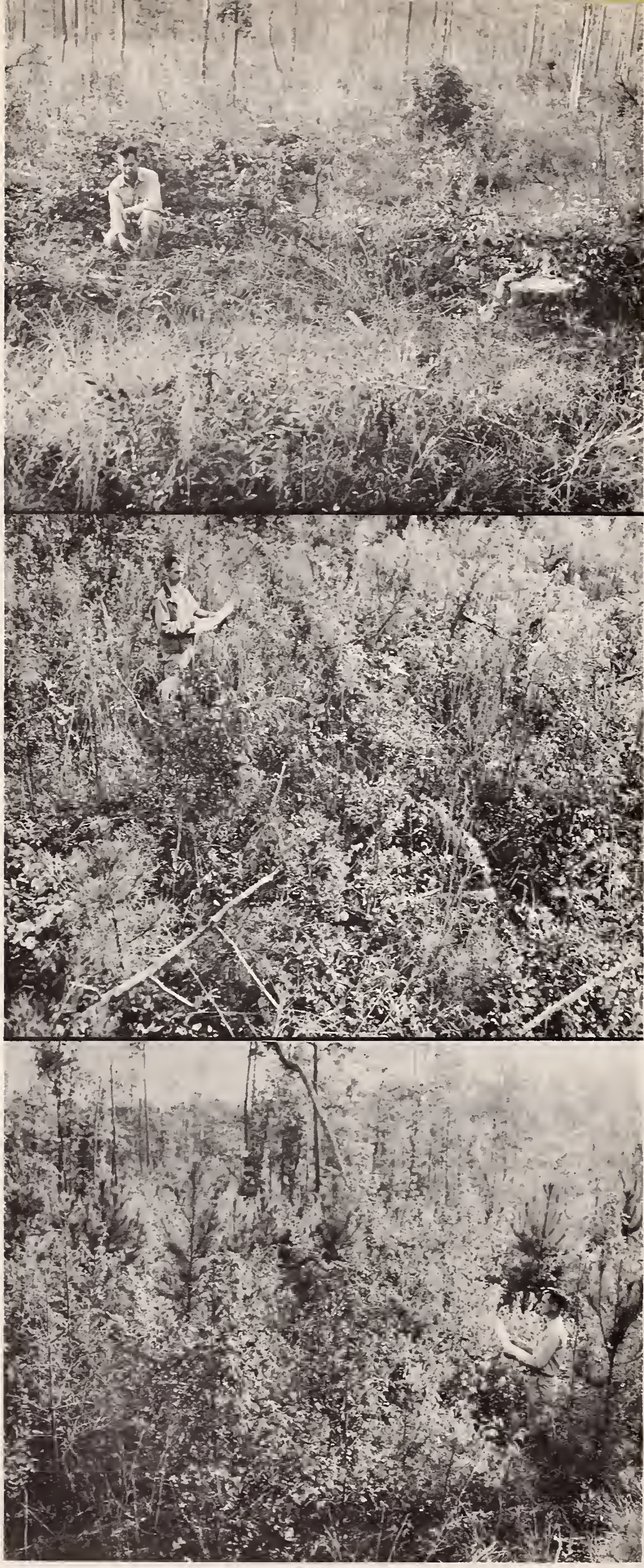

Figure 2.--Vegetation in clear cuttings in the first (top), second, and fourth years after disking and logging.

Table 1.--Mean heights of sprout clumps of five species, adjusted for differences in diameter of stump and age of sprout

Factors affecting sprout growth				Adjusted mean height of sprouts					
Season of:									
Clear cutting	Burning after clear cutting	Surface after treatment	Soil group [1/]	Sweet gum	Red maple	Red oak	Dog-wood	Wax-myrtle	35-acre tracts sampled
				Feet	Feet	Feet	Feet	Feet	Number
Summer	Summer	Burned	WP	3.86	4.28	3.01		2.71	2
Winter & Summer [2/]	Summer	Burned	WF	5.30	4.92	4.39	3.71	2.67	2
Summer	Summer	Burned	PP	3.33	3.57	1.99			1
Summer	None	Not burned	WP	4.74	3.97	2.90	3.94		1
Summer	None	Not burned	WF	4.49	4.18	3.17	3.89	3.17	3
Summer	None	Not burned	PP	4.00	3.58	3.21			1
Winter	None	Not burned	WP	4.77	4.90	3.61	4.52		1
Winter	None	Not burned	WF			6.20	3.84	3.02	1
Winter	None	Not burned	PP	4.71	5.16	3.30			1

1/ WP, well-drained plastic soils.
WF, well-drained, friable soils.
PP, poorly-drained plastic soils.

2/ Two 35-acre tracts clear cut in different seasons.

Wherever a comparison was available, sprouts from winter cuttings grew as fast or faster than sprouts from summer cuttings.

Up to 5 years of age, a 1-inch difference in stump diameter was associated with a difference of 0.5 foot in total height of sweetgum, red maple, and red oak sprouts; 0.3 foot in the height of dogwood sprouts; and 0.8 foot in the height of waxmyrtle sprouts. The majority of stumps were less than 4 inches in diameter.

Crown width and crown height [2/] increased in direct proportion to total height in all species except sweetgum. Therefore, these species retain the sprout clump form at least throughout the first 5 years. In sweetgum one sprout apparently assumes dominance quickly, so that lateral expansion remains practically at a standstill after an initial spurt of growth until a tree-like crown develops on the dominant sprout. Differences in environmental conditions and treatments had no effect on these relations.

The relative frequencies of occurrence of the species with respect to soil groups are presented in table 2. Because length of sampling strips on which sprout clumps were measured was the same for each species, the relative frequency of occurrence in the strips is an estimate of that in the area as a whole. With improved drainage and lighter texture of the soil, sweetgum and red maple become relatively less numerous, and red oaks, dogwood, and waxmyrtle become more so. Particularly notable is the virtual absence of dogwood and the scarcity of myrtle on the poorly-drained, heavy soils.

Table 2.--Relative frequencies of occurrence of sprout clumps of five hardwood species according to major soil groups

Species	Poorly-drained plastic soil	Well-drained plastic soil	Well-drained friable soil
	Percent	Percent	Percent
Sweetgum	41.5	39.0	26.0
Red maple	43.0	39.0	26.0
Red oaks	12.0	10.0	21.0
Dogwood	0.5	5.0	15.0
Waxmyrtle	3.0	7.0	12.0
Total	100.0	100.0	100.0

2/ Height to the widest part of the crown in the vertical plane, where crown width was measured.

DEVELOPMENT OF LOBLOLLY PINE SEEDLINGS

Appearance and Growth of Seedlings

Vigor of hardwood competition is an essential element of the stocking survey. Equally important is the vigor and status of pine seedlings, both dominant and subdominant. In the case of the subdominants we need methods for judging which ones will come through and which ones have little chance.

Figure 3 shows the relation of 1 year's height growth to several seedling characteristics. These relations are based on measurements of 500 seedlings that were not infested by the Nantucket pine moth (Rhyacionia frustrana (Comst.)) and that represented two ages, two soil groups, and burned or unburned soil surface conditions.

The following multiple correlation coefficients show how closely height growth was related to the specified seedling characteristics:

Height-diameter ratio and total height	0.96
Terminal bud length and total height	0.91
Needle length and total height	0.90
Number of branches	0.85

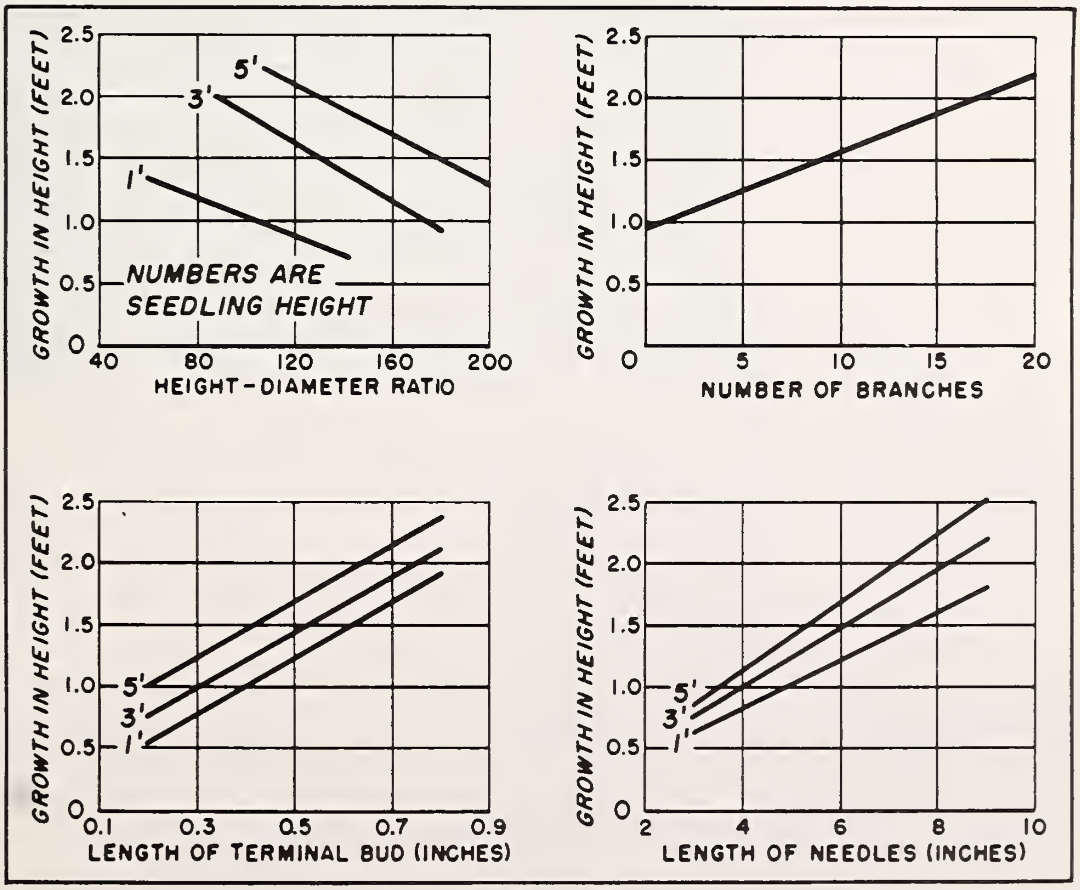

Figure 3.--The relation of 1 year's height growth to the indicated seedling characteristics.

Choice of the characteristic most suitable for field use depends in part on environmental conditions and age. With age taken into account, seedling height should be a good indicator of growth; and, since growth is the combined effect of all factors, past growth should also indicate future growth quite well. Of the four characteristics discussed above, the number of branches was promising for field use because its relation to seedling growth was linear and independent of seedling height and it could be determined without a measuring instrument. The effects of soil and seedling age on the relations of growth to these three seedling characteristics in the second year of the study are shown in figure 4. These effects on the branch and height relations were not significantly different from those in the first year.

The use of branching and seedling height as indicators of future growth is complicated by the influence of environmental factors. Height growth, however, reflects environmental differences in about the same way in one year as in the next. Consequently, the relation of current to previous height growth should be largely independent of these differences as long as environmental conditions do not change appreciably from year to year. The following correlation coefficients show how closely the current year's height growth was related to the specified seedling characteristics in the second year of the study:

Number of branches	0.87
Initial height	0.89
Previous year's growth	0.93

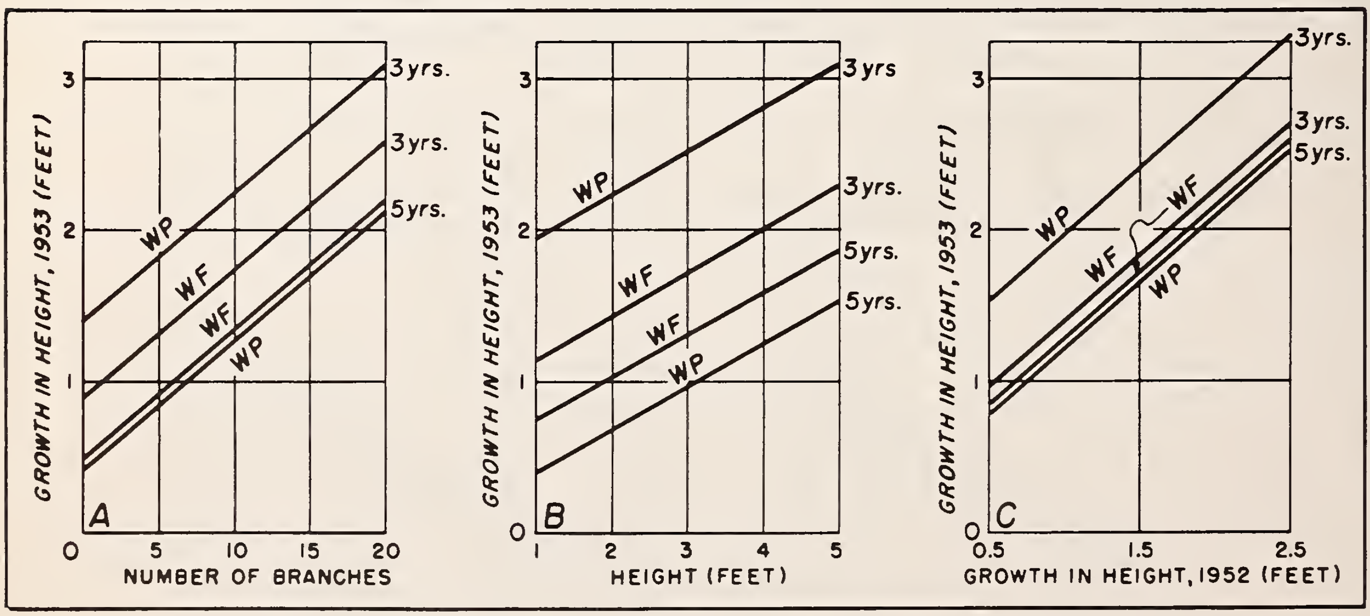

Figure 4.--The effect of soil and age on the relations of seedling height growth to number of branches, initial height, and previous growth.

The coefficient for previous year's growth is significantly higher than those for number of branches and initial height. Thus, of the seedling characteristics studied, past growth is the best criterion of future growth.

Effect of Release

Loblolly pine seedlings respond to release and grow well. Dying seedlings, with prematurely brown needles are, of course, an exception. In a small-scale test a number of 2-year-old seedlings were completely liberated by poisoning overtopping white oak trees with Ammate. The total height, terminal bud length, and color of foliage were recorded prior to release but all released seedlings responded to the treatment and none died (5). In a related study heavily suppressed, low-vigor seedlings collapsed upon release. In a short time they straightened up and grew well. The seedling in figure 5 was 1.7 feet tall and 4 years old when released; 2 years later it was 5.6 feet tall.

Figure 5.--Low-vigor, suppressed seedlings collapse when suddenly given complete release. But they soon straighten up and commence rapid growth.

A less complete form of release involving cutting but no poisoning was also tested. Over 400 4-year-old seedlings were selected in a clearcut area in 1947 and paired according to total height and vigor.[3] One of each pair was released by girdling large, residual, overtopping hardwoods and by cutting shrub and sprout growth for a distance from the seedling equal to one-half the height of the brush. The released seedlings grew more than the controls under all conditions during the next three years. Height growth alone, however, did not clearly indicate which of these seedlings would become dominant. Therefore, in 1952 the 9-year-old seedlings were classified into two groups, dominant and not dominant, so that the relation between treatment and the attainment of dominance could be examined.

3/ This study was installed by Kenneth B. Pomeroy.

Release significantly increased the percentage of seedlings that became dominant, but the percentage was significantly smaller where an overstory had been present, even though the overstory trees were girdled in the release treatment (fig. 6). Root competition probably was the cause, since the roots were not killed by girdling and were sustained by the sprouts.

Where low competition was light, the percentage dominant was so high that release could increase it but little. Release from heavy competition significantly increased the percentage dominant (fig. 7). However, even with release, less than 60 percent of overtopped seedlings became dominant.

These results show that liberation and cleaning are of doubtful benefit without poisoning to kill the roots so that no vigorous sprouting occurs. This point is further emphasized by the response to release in relation to moisture conditions, of which two distinct kinds existed in the study area. A significantly greater percentage of released seedlings became dominant on the dry site than on the moist site. The difference in control seedlings, although appreciable, was not significant (fig. 8). Sprouts were much more vigorous on the moist site and competed more strongly with the seedlings. Consequently, the response of pine to release was poorer even though the growing conditions were better in the moist area.

Insect Damage

Of the several insects that are commonly found attacking loblolly pine seedlings in the Southeast, the one that foresters are most concerned about is the Nantucket pine moth (*Rhyacionia frustrana* (Comst.)) usually referred to as the tip moth. Other insects, such as the red-headed pine sawfly, (*Neodiprion lecontei* (Fitch)), the pales weevil (*Hylobius pales* (Hobst.)), and the pine webworm (*Tetralopha robustella* Zell.), occasionally become of concern locally. The tip moth, however, seems to be present in considerable numbers in seedling stands throughout the Southeast at all times.

A single year's attack by the tip moth did not retard the growth of the seedlings. The study of the relation of growth to seedling characteristics was limited to seedlings that had no tip moth attack before the preceding year. Thus the influence of repeated annual attack was not considered in that study. The infested seedlings were located within the same plots as the undamaged seedlings, so that the two kinds were intermingled and subject to identical environmental conditions.

The release study, on the other hand, offered an opportunity to observe the effect of repeated attacks on the growth and dominance of loblolly pine seedlings. The record consisted of the number of years in which a seedling was attacked rather than the specific number of insect attacks. On that basis, each year of attack reduced seedling growth by 0.50 foot; that is, seedlings attacked in 1 year grew 0.50 foot less, seedlings attacked in 2 years grew 1.00 foot less, and seedlings attacked in 3 years grew 1.50 feet less than seedlings not attacked.

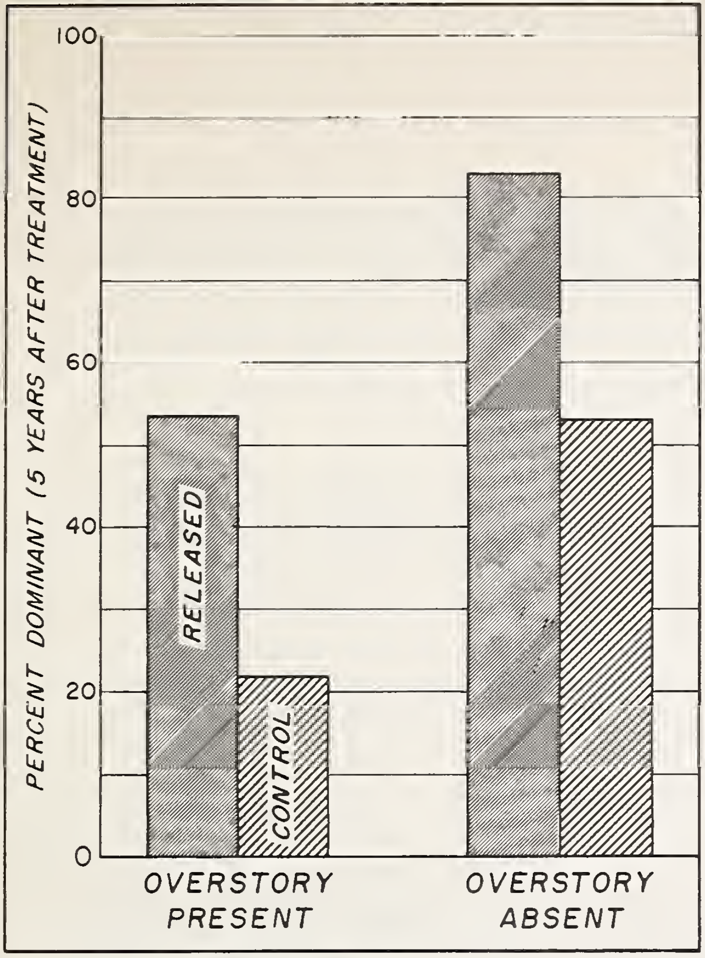

Figure 6.--Percentage of seedlings dominant 5 years after treatment, in relation to overstory conditions before treatment.

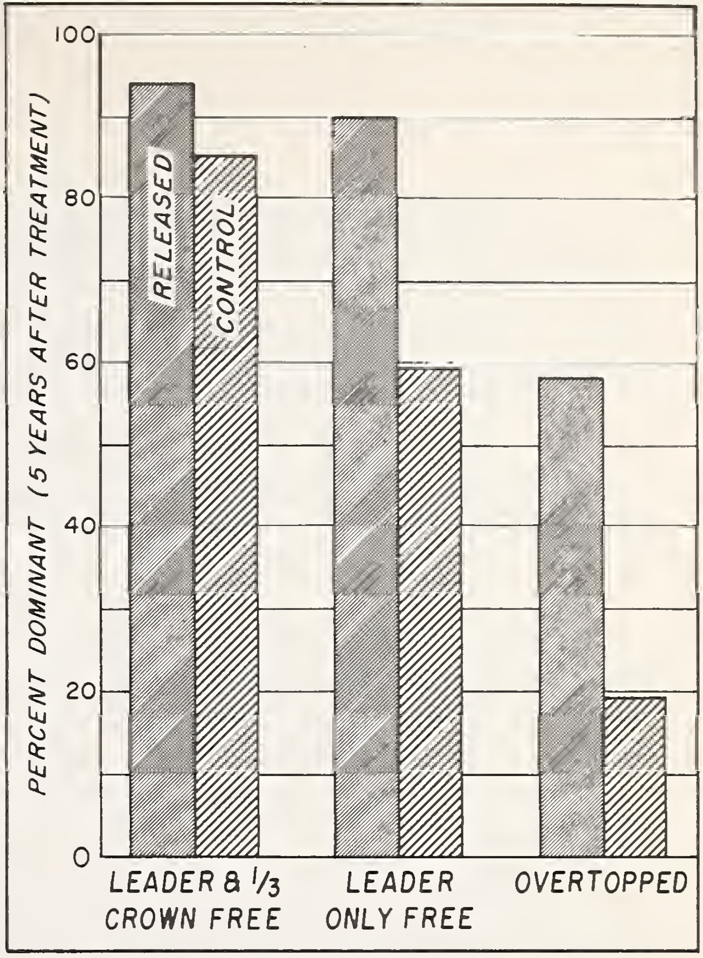

Figure 7.--Percentage of seedlings dominant 5 years after treatment, in relation to levels of low competition before treatment.

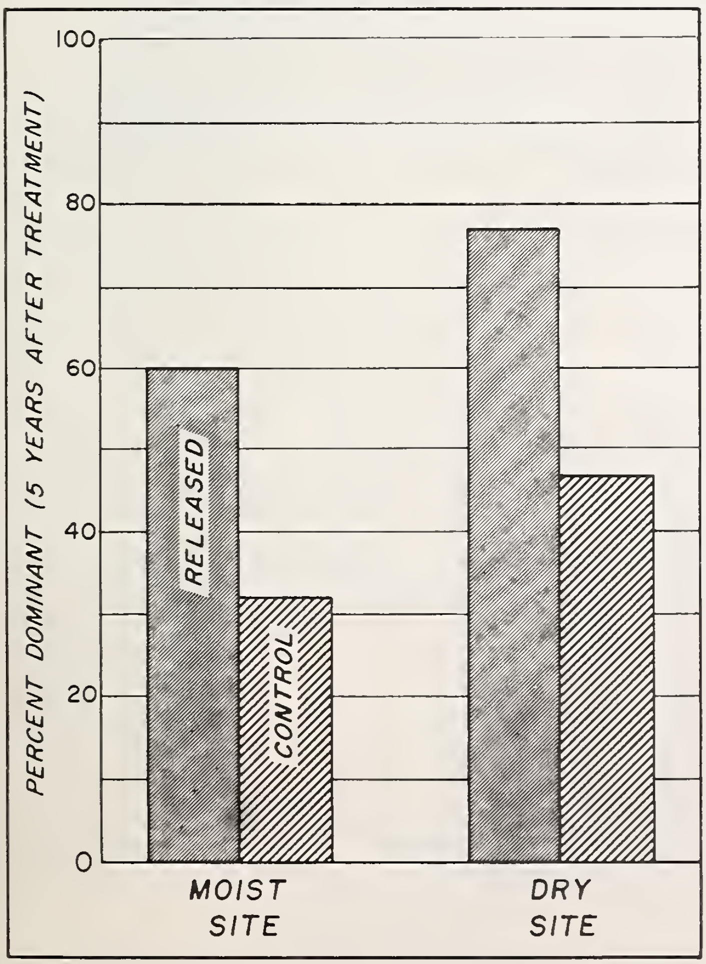

Figure 8.--Percentage of seedlings dominant 5 years after treatment, in relation to moisture conditions.

No association was found between frequency of attack and percentage dominant for either released or control seedlings. Tip moth attack therefore did not prevent seedlings from becoming dominant if other factors were favorable. Frequency of attack was high, 69.5 percent of all seedlings having been attacked once or more during the 3-year period.

A significantly higher percentage of released seedlings than control seedlings was attacked--74.5 percent compared to 63.9 percent. That behavior agrees with experience in other parts of the loblolly pine range (1). Overhead release of the seedlings apparently exposed them to more frequent attack.

This experience indicates that the tip moth usually is not a serious deterrent to the establishment of loblolly pine stands by natural regeneration. In plantations, however, attacks on some seedlings occasionally reach such an intensity that height growth is almost stopped.

Mortality

Reliable estimates of the stocking of potentially dominant seedlings cannot be made in the first year, not only because vegetative conditions are changing too rapidly but also because seedling mortality is high and largely due to factors other than competition. In the Bigwoods Experimental Forest, mortality among newly germinated seedlings was 7.5 percent in one year and 18.0 percent in another year, with a distinct tendency to be higher in lighter soil (4). After the first year, seedling prospects can be judged more reliably because mortality is much less and apparently is caused mainly by competition. Another study involving 2 year's records of 700 seedlings showed the following mortality rates among 2- to 5-year-old seedlings:

2-year-old seedlings (basis - 400)	1.1 percent
3-year-old seedlings (basis - 400)	1.7 percent
4-year-old seedlings (basis - 300)	0.4 percent
5-year-old seedlings (basis - 300)	0.1 percent

Heavy competition seems to favor other causes of mortality. Of the 445 seedlings chosen for the release study in 1947, 63 had died of natural causes by late 1952, five growing seasons later. Of these, 55 or 87.5 percent were overtopped by low competition although competition was considered the cause of death in only 32 of these cases. The causes of death are summarized in table 3.

HOW TO JUDGE SEEDLING PROSPECTS

The relations revealed by these studies are too complex to furnish a single, highly accurate criterion of future seedling dominance. However, the results suggest several simple, practical aids to judgment.

Table 3.--Causes of seedling mortality (during 5 years from 4 years to 9 years of age

Cause of death	Low competition: Leader free	Low competition: Overtopped
	Number of seedlings	
Competition	2	32
Fusiform rust	0	2
Sawfly	5	13
Pine webworm	0	3
Rodents	0	2
Miscellaneous and unknown	1	3
Total	8	55

For seedlings among sprout clumps, a comparison of the height and past growth of the seedling and sprout clump will help to resolve doubtful cases. In loblolly pine seedlings the relation between current year's growth in feet (y) and previous year's growth in feet (x) was found to be:

$$y = 0.35 + 1.02x$$

This expression shows that, on the average, the height growth of pine seedlings during the first 5 years tends to increase somewhat in each succeeding year. The height growth of hardwood sprout clumps, on the other hand, tends to decrease during the same period. These tendencies are illustrated by the trends of height growth shown in figure 9.

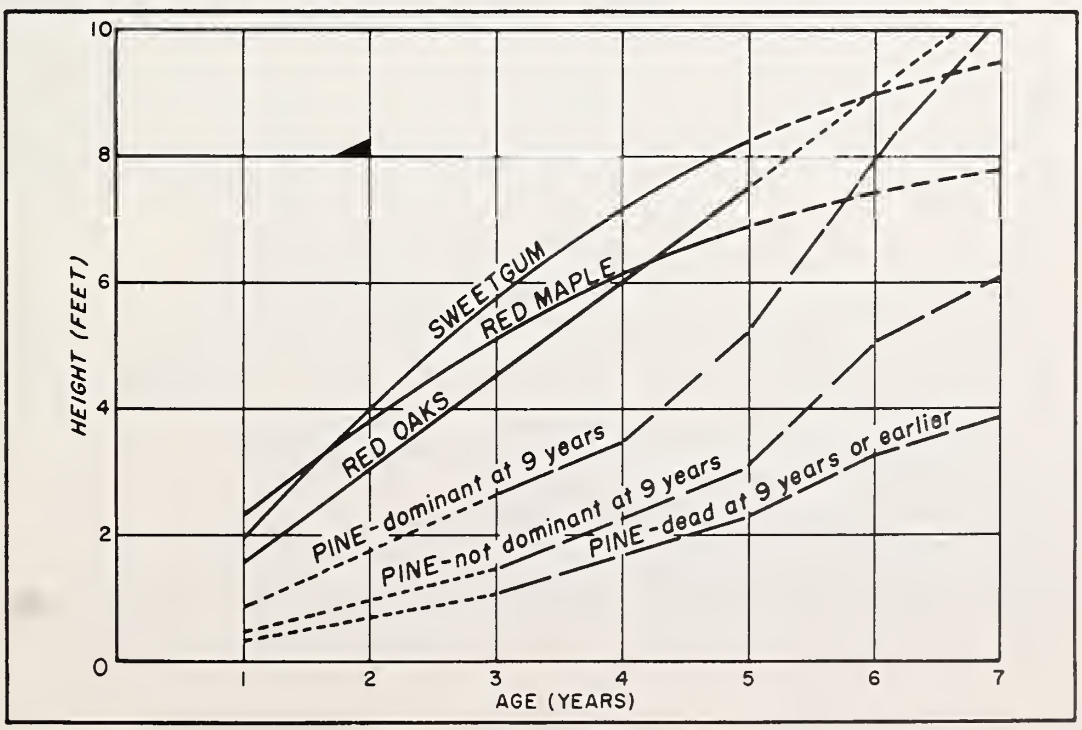

Figure 9.--Growth of hardwood sprout clumps and loblolly pine seedlings under average conditions.

Past growth of most hardwood species can be distinguished quite readily by the color and texture of the bark and the ring of scars left by the scales of the terminal bud at the beginning of growth. The several surges of growth made in one season by most loblolly pine seedlings may confuse some observers. Two or three branch whorls commonly occur within one year's height growth. The first internode usually is the longest and succeeding ones are progressively shorter. These sets of internodes frequently are so distinct that each year's growth can be distinguished on seedlings as much as 5 years old (fig. 10). The difference in appearance of needles on the main stem also helps to separate current from previous growth during late summer, when uncertainty is most likely. The older needles are duller, darker in color, and feel more brittle. Later in the fall these needles are cast and only the latest crop remains on the stem.

While such a comparison of prospective growth rates will help a careful observer estimate the stocking of potentially dominant seedlings, better results probably can be obtained by using the information on pine seedlings and hardwood sprout-clump behavior to enhance the reliability of two somewhat more objective criteria of eventual dominance. The growth of hardwood cover has slowed down to a low, constant rate by the third growing season (fig. 1); consequently, pine seedlings with their leaders free at that time or later should have a good chance of surpassing the hardwood competion. How good a chance is shown by the results of the release study (fig. 7), where 72 percent of seedlings with their leaders free at 4 years had become dominant at 9 years. In addition, 79 percent of the overtopped seedlings did not become dominant. Predictions based only on overtopping at 4 years would have been 74 percent correct. That level of accuracy, already fairly good, can be raised by modifying the predictions according to the comparative height, position, and growth of the seedlings and competing sprout clumps. For example, although a seedling is closely overtopped by a sprout clump, its past growth may show that it will easily grow through the single layer of hardwood foliage (fig. 11). On the other hand, a seedling with the leader free, beside a much taller sprout clump, may clearly have too far to grow before being engulfed by the expanding hardwood crown.

A second method is based on the height of seedlings at a given age. Seedlings were grouped into height classes at 3, 4, and 5 years of age and the percentage dominant at 9 years determined for each class at each of the earlier ages. Figure 12 illustrates the results of that procedure for 4-year-old seedlings. It is evident that at 4 years the critical height for eventual dominance is about 2 feet. If eventual dominance had been predicted for all seedlings taller and suppression for all those shorter than 2 feet at 4 years, 73 percent of the predictions would have been correct. For any other height the percentage of predictions correct would have been less. Critical heights were determined in the same fashion for 3- and 5-year-old seedlings, with the following results:

3-year-old seedlings - - - 1.5 feet (72 percent predictions correct)
4-year-old seedlings - - - 2.0 feet (73 percent predictions correct)
5-year-old seedlings - - - 4.0 feet (75 percent predictions correct)

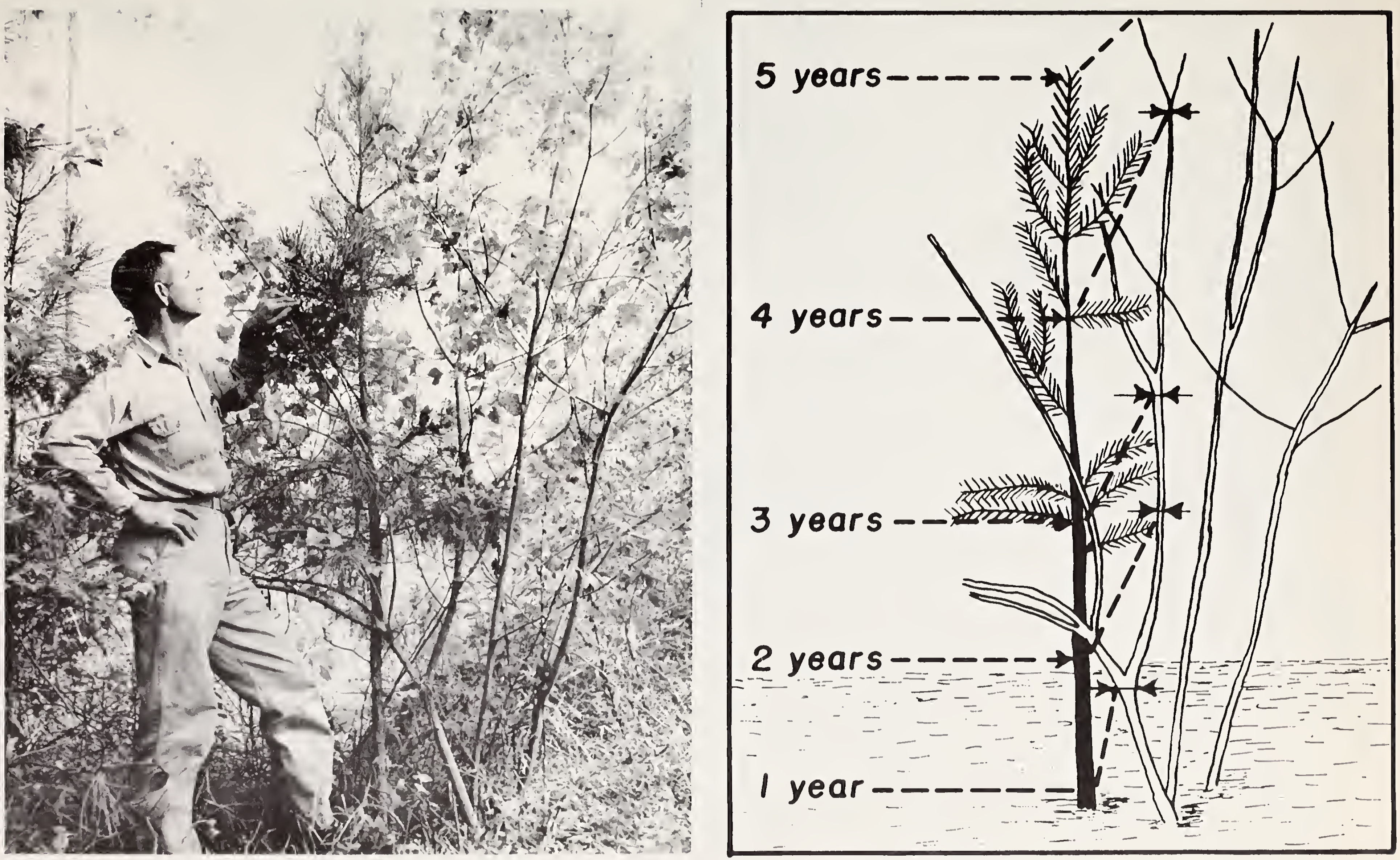

Figure 10.--Height and position of a loblolly pine seedling and the clump of maple sprouts through which it grew. Notice particularly the increasing rate of height growth of the pine seedling.

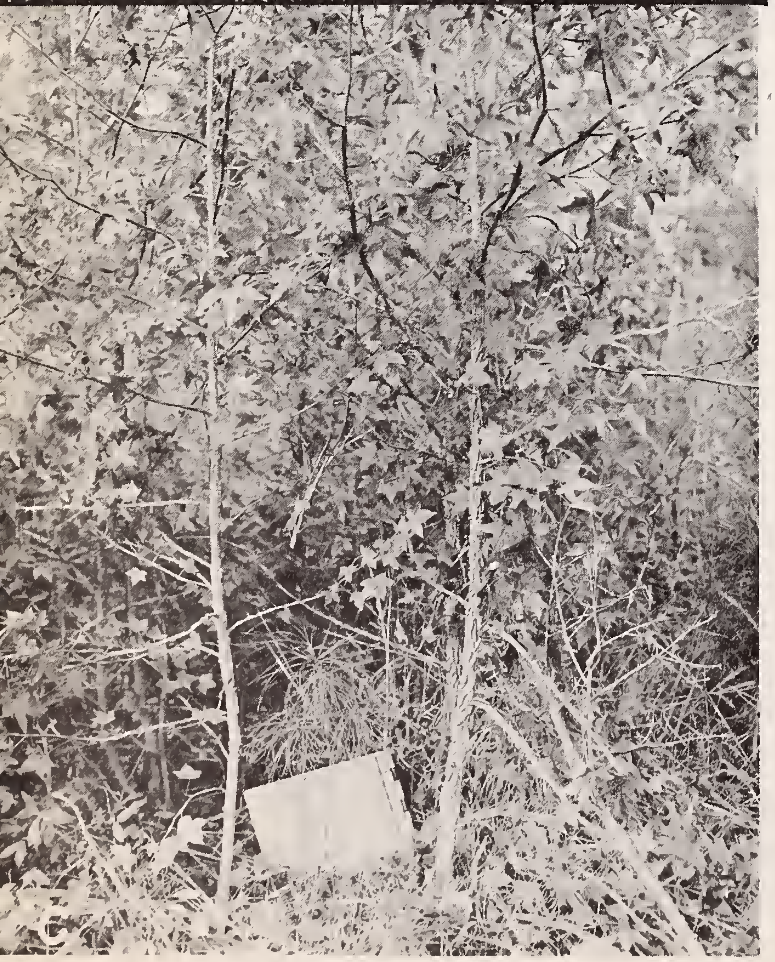

Figure 11.--A, A good prospect. One limb of oak competitor is over the seedling, but the seedling is growing fast enough to get past it in the next growing season. B, Another good prospect. Although overtopped, the competitor is a slow-growing huckleberry bush. Judging from past growth, the seedling will leave the shrub behind in the next year. C, Hopeless. Inside the thicket of sweetgum sprouts the seedling is shaded from above and on all sides (sprouts and branches were cut facing the camera to get the picture).

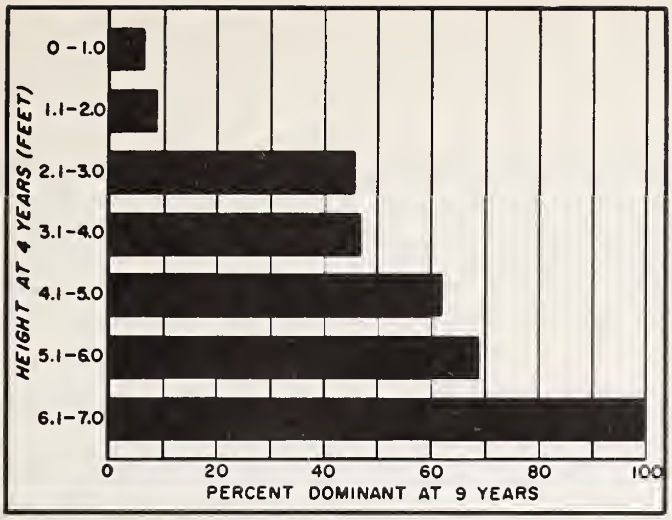

Figure 12.--Percentage of loblolly pine seedlings dominant at 9 years of age, according to height at 4 years of age. The percent dominant applies only to seedlings within the height range specified at left, and not to all seedlings above that height.

The two criteria of prospective dominance first described, comparative growth rates and free leaders in the third, or later, year of age, are applicable on any upland site since they are based on relative position of seedlings and hardwood competitors. The critical height method is applicable only on similar soils, however, because seedling height growth is influenced by soil characteristics. The seedlings that were the basis for that method were located on an area of well-drained sandy loam with a friable, sandy clay subsoil. Therefore, the method can probably be used in many areas in the southeastern coastal plain, where well-drained and moderately well-drained sandy loams are frequently encountered.

THE REPRODUCTION SURVEY

Estimates of reproduction are best made by the stocked quadrat method because it reflects not only the number of seedlings present but also their distribution. In that method small plots or quadrats are tallied as stocked if one or more seedlings of the desired species are present. The number of plots stocked divided by the total observed then gives the stocking percent. In loblolly pine a convenient and satisfactory plot size is one milacre (1/1000 acre). Plots are located in some predetermined fashion so that all parts of the area in question are sampled. For some purposes a random distribution may be needed but in practical work a systematic scheme is probably satisfactory in most cases. Reproduction surveys in the Bigwoods Experimental Forest utilize 100 milacre plots per 35-acre tract.

Opinions as to what constitutes adequate milacre stocking vary anywhere from 40 to 90 percent, that is, 400 to 900 well-distributed, free-to-grow seedlings per acre. To determine the need for further treatment, both the total present stocking and the stocking of potentially dominant seedlings must be estimated. If the total is below standard, release work would be inadequate, and some other treatment to establish more seedlings is needed. Only about 85 percent of the seedlings judged free to grow will actually become dominant.

The survey method can be modified in a number of ways to yield additional information for planning future work. One useful refinement is to record the kind of competition--residual hardwood trees or low brush--for plots stocked with a suppressed seedling. The tally would then show whether the pine seedlings need release from overhead competition or low competition or both.

If all plots are classified according to type of cover, whether seedlings are present or not, a rough estimate of the area under each type of cover can be obtained by applying the percentage of plots in each type to the whole area. If, in addition, the identity of individual plots is retained in the field record, the parts of the tract that need treatment can be located, since the direction of line and the plot interval are known.

If more precise estimates of types of hardwood cover are needed, they can be obtained by a line-intercept survey made while moving along the cruise lines, or by a further modification of the plot survey. In the line-intercept method, the observer simply records the distance traveled through each type of cover along the line. The percentage of the total length of line in each type applied to the total area yields an estimate of the acreage in each cover type. Again, by maintaining the identify of plot intervals, heavy concentrations of each cover type can be located. Another method of obtaining more precise estimates of the area occupied by residual hardwood trees is to tally hardwood stems on a larger plot at some of the milacre plot locations. Surveys utilizing thirty 1/10-acre plots per 35-acre tract have provided estimates of basal area of hardwoods accurate to within 10 percent of the actual basal area. The basal area in hardwood stems multiplied by 1.4 yields an estimate of the percent of total area occupied by hardwood crowns (3). And the number and diameter of the hardwood stems furnish a basis for estimating the cost of poisoning them with Ammate. McClay (2) found the following relation between hardwood stems and the time required to treat them with Ammate:

$$\frac{\text{man-hours}}{\text{per acre}} = 0.009\ (\text{sum of tree diameters}) - 0.005\ (\text{number of trees per acre})$$

For stems under 6 inches d.b.h., one-third the basal area in square feet per acre will give a rough estimate of man-hours required for poisoning with Ammate.

SUMMARY

When natural regeneration is relied upon in the even-aged management of loblolly pine, the stocking of dominant and potentially dominant seedlings should be estimated as soon as possible to find out whether further treatment of the reproduction area is necessary. Study of the growth and development of pine seedlings and their hardwood competitors revealed relations too complex to furnish a single, highly accurate criterion of future seedling dominance. However, the following aids to judgment were developed:

1. Comparison of past height growth and relative positions of pine seedlings and competing sprout clumps. The annual height growth of pine seedlings, especially those likely to become dominant, tends to accelerate in succeeding years, while height growth rates of hardwood sprout clumps tend to decrease.

2. Overtopping in the third year or later. The growth of hardwood cover has slowed down to a low, constant rate by the third growing season. Pine seedlings not overtopped by that time have a good chance of becoming dominant. Seventy-two percent of seedlings with their leaders free at 4 years had become dominant at 9 years.

3. Seedling height at a given age. Seedlings that are 1.5 feet tall or taller at 3 years, 2.0 feet at 4 years, and 4.0 feet at 5 years of age, are likely to be dominant by 9 years of age. This method of judging prospective dominance is applicable only on a well-drained and moderately well-drained sandy loams in the coastal plain.

The stocking survey can be made to yield an estimate of pine stocking only, or can be modified to show in addition the kind and location of hardwood competition as a basis for planning any required cultural work.

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